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Final Report

2.1-18
(Extension of 2.1-13)

Incidence of Translocations in Beef Bulls

Conducted by Sheila Schmutz

Funded by the Agriculture Development Fund

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FINAL REPORT

Sheila M. Schmutz

November 1, 1989

Incidence of Translocations in Beef Bulls

a) Abstract

Eighty-three bulls of 10 different beef breeds were karyotyped during this study. Abnormal karyotypes were found in 3 animals. Two bulls carried one copy of the 1;29 translocation and one bull carried two copies. No association of scrotal circumference with risk of carrying the translocation was found. No evidence of the translocation was found among the 25 bulls of the British breeds: Hereford, Angus, and Shorthorn.

b) Technical Report -appended

c) **Presentations:**

Schmutz, S. M. and J. S. Moker. July, 1989. Incidence of the 1;29 Robertsonian translocation in western Canadian beef cattle. 5th North American Colloquim on Cytogenetics of Domestic Animals, Purdue University, West Lafayette, Indiana.

Schmutz, S. M. and J. S. Moker. Feb. 25, 1989. Impact of a 1;29 Robertsonian translocation on a herd of purebred Charolais cattle. Canada West Society of Reproductive Biology Conference, Saskatoon.

Schmutz, S. M. March 3, 1989. Fertility affects of chromosome rearrangements. Saskatoon R.O.P. Bull Test Station Field Day, Saskatoon.

Refeered Publications:

Schmutz, S. M. and J. S. Moker. 1989. Impact of a 1;29 Robertsonian translocation on a herd of purebred beef cattle. Can. J. An. Sci., in press. (also summarized for AgriScience)

Reports:

Coulter, G. H., R. J. Mapletoft, S. M. Schmutz. 1989. Chromosomal abnormalities in cattle. Submitted to the Expert Committee on Animal Breeding and Reproduction, Ottawa.

Popular Articles:

Dr. Sheila Schmutz was interviewed and quoted in:
Thomas, Larry. June 1989. Chromosome fusion reduces fertility. Cattlemen.

d) expenditure summary - appended

e) Dr. Sheila Schmutz has spent 20% of her time on this project.
Mrs. Jane Moker has spent 70% of her time on this project.
Dr. Reuben Mapletoft and Albert Barth collected blood samples as part of clinic time.

f) No item of equipment of greater than $500 in value was purchased.

Summary

Reductions in fertility among beef cattle may be difficult to detect even though reproductive potential accounts for the major profit to the producer. Much of western beef production is still a result of bulls in natural service. In most cases commercial herds of cattle are run in relatively large groups with many cows but also several bulls. It is well known that bulls develop a dominance hierarchy among themselves and therefore it is never a surprise to a producer that each bull does not necessarily sire an equal number of calves. Likewise, even when three to four bulls are present for every hundred cows, it is expected that in the fall some of the cows will be open.

Artificial insemination is used more commonly among beef breeds than in the past and has certainly become the dominant breeding method in the dairy industry. Again, some cows do not conceive after a single A.I. attempt. Often this is chalked up to inexperience on the part of the technician or loss of viability of sperm due to freezing.

One subtle cause of a "higher than expected number" of cows open can also be a chromosome problem. It is common knowledge that freemartin calves will rarely conceive but it is less well known by producers that their male co-twin will also often have reduced fertility. The reproductive problems of both calves are caused by an exchange of cells between them which results in both calves being a little bit male and a little bit female.

Another chromosome problem which reduces fertility in both sexes is called a Robertsonian translocation. Such a translocation is the result of a fusion of two chromosomes into one larger one. This leaves the animal with an uneven number of chromosomes, 59 instead of 60. This uneven number poses no problem to the animal until it produces gametes. Some gametes will be perfectly normal with 30 chromosomes and some will have only 29 but include the translocation and be just like its parent. Unfortunately a few of the gametes will receive a mismatched set of chromosomes and will not survive to birth. These abortuses probably occur relatively early in pregnancy, probably before fall pregnancy checking. Therefore most producers would not have recorded these reproductive losses as abortions but rather as open cows. If A.I. is in use, rarely will the bull or dam be thought of as responsible. If there are only a few translocation cows are in a herd under natural service and these

cows are "open", it is often assumed they never conceived rather than that they aborted.

This is the reason that the translocation involving chromosomes 1 and 29, the largest and smallest chromosomes, can spread in a herd or breed without any knowledge on the part of even "elite" breeders. This translocation has been found in virtually all of the continental breeds of beef cattle and in some of the British dairy breeds. In Saskatchewan, 4 of 51 subfertile bulls and 3 of 83 bulls predicted to be of normal fertility were found to carry this translocation.

The translocaiton causes low levels of abortions or "open" cows, in the range of 10%, if carried by a bull. Reproductive losses may be slightly higher when the cow is the carrier. It does not produce sterility nor loss of libido, unfortunately, because then it would be selected out. Nor does size scrotal circumference serve as an indicator of the problem. Luckily there is a test for this abnormal chromosome arrangement which can be used to detect individual carriers. Not all progeny from carriers need be culled since approximately 50% receive the normal chromosome combination.

Vigilant study of herd records and productivity, especially in purebred herds where individual sires are used on groups of cows, should lead to suspicion of particular bulls who leave 10% of more of the cows they service open. On the other hand, herds with 5-6% of cows open can probably assume none of the bulls have this translocation. If short term mating seasons are used, some cows with the translocation will abort early and show up as open in the fall and presumably be culled on this basis.

Technical Report

Sheila M. Schmutz

November 1, 1989

Incidence of Translocations in Beef Bulls

Abstract

Eighty-three bulls of 10 different beef breeds were karyotyped during this study. Abnormal karyotypes were found in 3 animals. Two bulls carried one copy of the 1;29 translocation and one bull carried two copies. No association of scrotal circumference with risk of carrying the translocation was found. No evidence of the translocation was found among the 25 bulls of the British breeds: Hereford, Angus, and Shorthorn.

Background and Objectives

An animal's basic genetic material is carried on structures called chromosomes. Cattle normally have sixty chromosomes. All but the sex chromosomes normally have the centromere (the region of the chromosome which pulls the dividing chromosome into daughter cells) at the end and are therefore referred to as acrocentric chromosomes. Occasionally two chromosomes will fuse (Robertsonian translocation). This results in one chromosome besides the sex chromosomes having a centromere not placed at the end, and also results in a reduction in total number from 60 to 59.

Such Robertsonian translocations fall into the category of "balanced chromosome rearrangements" because no parts are lost or added, but merely altered in position relative to one another. Balanced rearrangements cause no immediate phenotypic abnormality in the individual which posesses one. Usually, however, reproductive problems ensue (Boue et al. 1985). These lead to subfertility and occasionally infertility. Early embryonic loss often results and can cause prolonged calving intervals, delayed return to estrus and repeapt breeding, low success after artificial insemination, etc. Depending on the chromosomes involved, pregnancies may continue beyond the first three months but give rise to malformed abortuses or calves. This represents an even greater economic loss.

Several balanced translocations which cause reduced fertility have been described in cattle (Eldridge 1985, McWhir et al. 1987). Reduced fertility has been demonstrated in carriers of a particularly common translocation of chromosomes 1 and 29 (Gustavsson 1979, Dryendahl and Gustavsson 1979, Schmutz and Moker 1989). Some estimates report that 7% of some purebreed herds may carry this translocation and 8-20% incidence has been reported in the subfertile cohort (Bongso and Basrur 1976, King and Linnares 1983, Swartz and Vogt 1983, Maurer and Echternkamp 1985). Reduced fertility, particularly among carrier females, has been reported

(Refsdahl 1976). No unbalanced liveborn offspring to parents carrying this 1/29 translocation have been reported, but carrier status is transmitted to approximately 50% of the liveborn offspring (Gustavsson 1979).

Since the risk of this translocation is predicted to be higher in subfertile animals than those of normal fertility and since bulls are used more extensively than individual females, the primary focus of this study was beef bulls rather than cows. The first portion of this study in 1988 focussed on beef bulls with some sign of subfertility. The second portion, reported here, foucussed on beef bulls predicted to have normal fertility. The primary objective was to determine if chromosome abnormalities are carried by Saskatchewan beef cattle. Secondarily, we wished to make recommendations to individual owners regarding the testing of relatives of such translocation carrying animals to assist in eradication. This should ultimately increase the conception rate and decrease embryonic loss in herds with affected animals.

Experimental Methods

Eighty-three bulls from 10 different beef breeds were studied. Most of these bulls were entered in the Saskatoon R.O.P. bull test station in fall1988. All producers who entered bulls were contacted and authorization to draw blood samples for karyotyping was requested. Most producers agreed. One bull was sampled from each group whose owner requested testing. In all cases the bull was of normal scrotal circumference (>32 cm.). The remaining bulls sampled were presented to either Dr. Barth or Dr. Mapletoft for examination at the Western College of Veterinary Medicine and were found to have normal scrotal circumference and no other sign of subfertility such as sperm defects.

A heparinized blood sample was collected sterilely from each animal. Cultures were established using 10 ml of Ham's F10 medium (containing 20% fetal calf serum, gentamycin, and fungizone), 8 drops of blood and 0.2 ml of phytohemaglutinin. Cultures were incubated at 37^{0} C in a CO_2 incubator for 3 days. One hour prior to harvest, 0.1 ml of colcemid was added to arrest cell division in metaphase. The cells were exposed to a hypotonic solution (0.75 M KCl) for 15 minutes, fixed with a 3:1 solution of methanol: acetic acid overnight and washed 2-3 times before slide preparation. An attempt was made to analyze 15 cells (minimum was 10) from each individual microscopically to rule out mosaicism at the 10% level with 95% confidence (Hook 1977). Photomicrographs were also taken and analyzed.

Results and Discussion

The numbers of bulls of each of the ten breeds sampled during this 1989 study are presented in Table 1. The numbers studied from each breed primarily reflects the numbers of each breed entered in the Saskatoon R.O.P. test station and is not necessarily representative of the actual numbers present of each in the province.

Table 1. Breeds of Bulls with Normal Fertility Karyotyped

Angus	10
Blonde d'Aquitaine	1
Charolais	28
Hereford	12
Limousin	6
Maine-Anjou	4
Salers	1
Shaver	1
Shorthorn	3
Simmental	17
TOTAL	83

Three bulls of the 83 studied had an abnormal karyotype (Table 2). One bull with a translocation was a Simmental and the other was a Charolais. The bull with two copies of the translocation was also a Charolais. As has been documented previously, no evidence of translocation was found among the British breeds. Blonde d'Aquitaine, Limousin and Maine-Anjou have all been previously reported as having this translocation but numbers sampled in this study were low. Only one Salers was studied and again this is therefore no indication that this breed is clear.

Table 2. Karyotypes of Normal Bulls.

Interpretation	Karyotype	No.
Normal	60,XY	80
1/29 Translocation	59,XY,t	2
	58,XY,tt	1

Levels of the translocation found in this study of bulls with normal fertility (3/83) approximate that found in our previous study of subfertile bulls (4/51). In the subfertile bull group, one chimera was also found. Table 3 shows that no significant difference in the number of bulls with abnormal karyotypes was found between the fertile and subfertile groups even though proportions might suggest otherwise. McWhir et al. (1987) found 10 cattle out of 253 (2.5%) to have abnormal karyotypes in their study in Alberta.

Table 3. Number of bulls with normal and abnormal karyotypes.

	Normal Fertility	Subfertility
Normal Karyotype	80	46
Abnormal Karyotype	3 (3.6%)	5 (10%)

$X^2 = 2.16$ $P = .14$

Karyotyping is a time consuming and therefore expensive test to conduct. Ideally if some physical trait were associated with the translocation, this could be used as a marker. Unfortunately some producers recently began to believe it is associated with horns which is not the case. No such physical trait is readily visible in translocation carrier animals. If some trait were at least more common, then it could be used to identify animals at increased risk.

Scrotal circumference was measured on all bulls karyotyped in both studies. Figure 1 illustrates the number of bulls in each scrotal size category. Bulls with abnormal karyotypes were not necessarily of small scrotal size. Unfortunately therefore, this more easily measured trait can not be used to identify bulls at increased risk of carrying the translocation.

This translocation has been shown to reduce fertility by approximately 10% in bulls carrying it. Three bulls were identified in this study. One owner chose to take action and eliminate it from his herd. The bull had inherited the translocation through the dam in this case. Her offspring were tested as well as half-sisters in the herd. Translocation carriers have been eliminated. Although this cow had been producing calves for the past three years, she aborted twice this summer and was culled. The other two producers with translocation carrying bulls, although offered similar access to testing, have not contacted our lab at this time. All owners of R.O.P. bulls which were tested were mailed certificates indicating the outcome of testing.

At the end of last year, 24 cows from a purebred Charolais herd where a translocation sire had been used for a few years had been tested. Testing is this herd has continued until the entire herd of 94 animals was completed (Fig. 2). Results of this study and the impact on fertility were summarized and submitted for publication. This paper will appear in the December issue of the Canadian Journal of Animal Science.

Updates have been sent periodically to the Canadian Charolais Association and Dr. Schmutz is now a member of the subcommittee they have struck to make information and recommendations available to their breeders. One meeting was also

Figure 1. Scrotal circumference measurement comparison of bulls with normal and abnormal karyotypes.

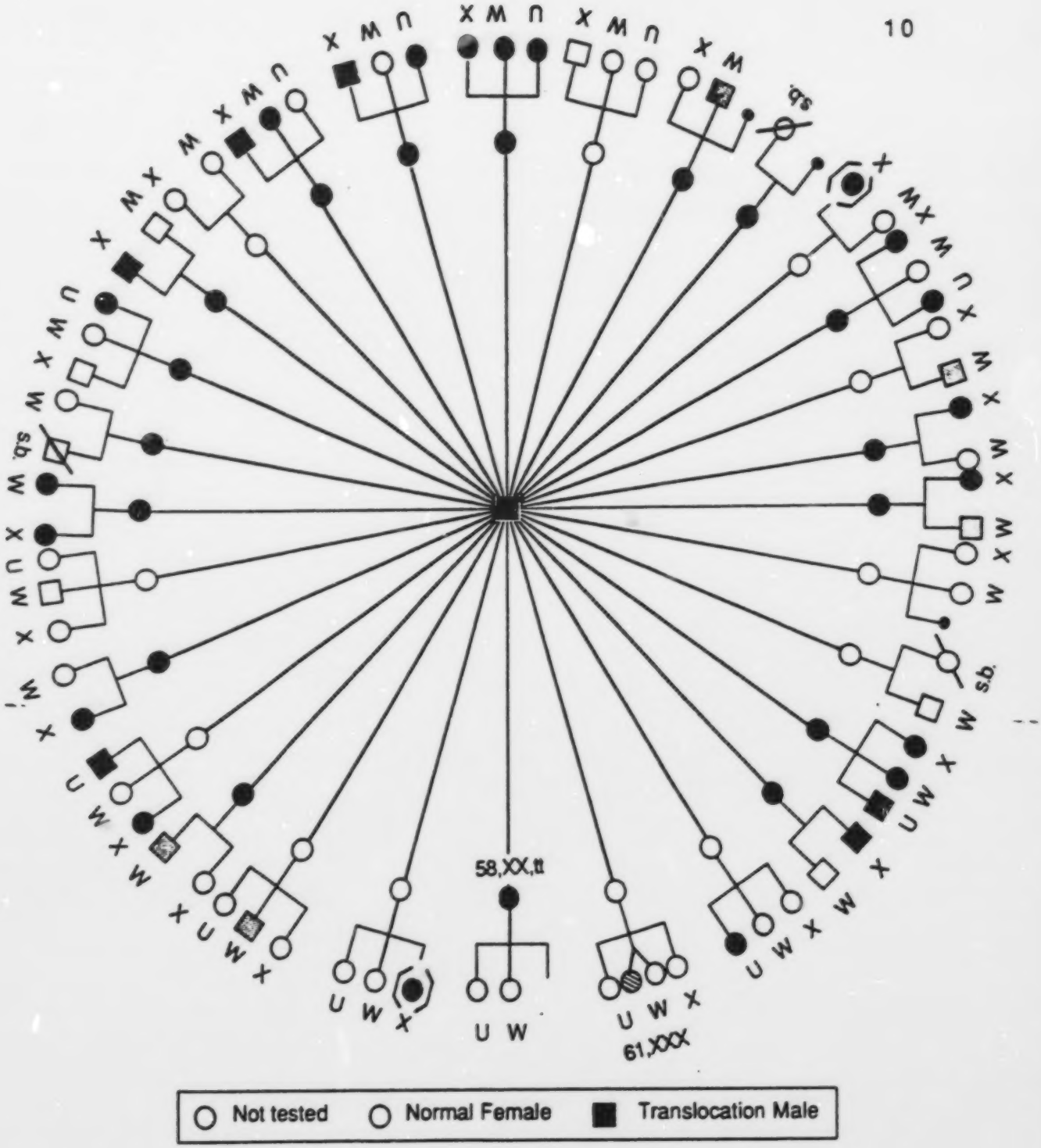

Figure 2. Pedigree of a herd of purebred cattle showing spread of translocation through one affected bull. The U calves were sired by an untested bull who may have been a carrier since he was the son of the original bull. The W and X calves were sired by a bull with a normal karyotype.

held with the Canadian Simmental Associaiton. Dr. Schmutz was also made a member of an ad-hoc advisory committee, chaired by Dr. Glen Coulter, of the Expert Committe on Animal Breeding and Reproduction. A report entitled "Chromosomal Abnormalities in Cattle" was drafted by this sub-committee and is attached.

Conclusions and Impact

This study indicates that Saskatchewan beef bulls are carrying the 1;29 translocation at this time. Further studies in one herd of cattle where replacement cows had been kept from a carrier bull indicated that fertility is impaired but can be somewhat reduced by alterations in management (Schmutz and Moker, 1989). The translocation has been found only in continental beef breeds thus far. Scrotal circumference can unfortunately not be used as an indicator of risk of carrying this translocation. Thus far no physical trait which can be readily identified has been found. The only indication of the translocation appears to be a reduction in fertility of 5-10%. Recognition and awareness of this problem in purebred beef bulls has dramatically increased since the onset of this study. Several producers have asked for testing to be done on herd sires with approximately 150 diagnostic cases handled in our lab this year. Recently training of a third technician for such analysis is being completed. She will begin to handle diagnostic cases through the Bovine Blood Testing Lab at the Saskatchewan Research Council Lab in Saskatoon in 1990.

Acknowledgements

We gratefully acknowledge financial support from the Canada-Saskatchewan ERDA agreement. We wish to thank the bull owners who so graciously allowed us to take of blood sample for chromosome analysis in this study and the Saskatoon R.O.P. bull test station members for their cooperation. We also wish to thank Dr. Roger Cohen and Bill Kowalenko for their assistance at the test station. Expert technical analysis was provided by Jane Moker and Marie Hanson. Scrotal circumference measurements were done by Drs. Reuben Mapletoft, Bill Cates, and Albert Barth of the Western College of Veterinary Medicine.

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UNIVERSITY OF SASKATCHEWAN
Saskatchewan Agriculture
"Incidence of Translocations in Beef Bulls"
Under the Direction of S.M. Schmutz, Animal & Poultry Science
Statement of Receipts & Expenditures for the Period
March 1 - September 30, 1989

Receipts

Unexpended balance as of February 28, 1989	$ 6,814.41	
Government of Saskatchewan - May, 1989	10,000.00	
Total Funds Available		$16,814.41

Expenditures

Salaries	$16,695.47	
Fringe Benefits	844.23	
Materials & Supplies	6,635.91	
Telephone	183.74	
Printing/Photocopying	18.15	
Travel	514.75	
Equipment	1,922.16	26,814.41
Overexpenditure as of September 30, 1989		$(10,000.00)

COPY FOR YOUR RECORDS

Sheila Schmutz
PROJECT DIRECTOR

M.G. Smith
M.G. SMITH
RESEARCH ACCOUNTANT